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INFLUENCE OF SOIL REACTION ON EARTHWORMS

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After the brilliant studies by Darwin (2) and P. E. Müller (5) of the animal life in the soil, especially of the differences between raw humus and mild humus, it has been generally (6) assumed that the formation of these different soil types is, to a great extent, due to the presence or absence of certain animals.

Against the hypothesis presented in Öcologische Studien (1) that in the case of raw humus and mild humus the formation of the different soil types was chiefly dependent upon the hydrogen-ion concentration of the soils, objection could be made that the animals in the soil caused both P_H and soil-type. As it is of very great importance to know whether this be true or not, the following experiments have been carried out. The first experiment, in the Treublaboratorium of s'Lands Planentuin, Buitenzorg, was with the usual Javenese earthworm, *Perichaeta indica,* Horst.[1] A certain number of equal size were placed in pots containing good garden soil from the Botanical Garden, and the separate pots were treated with acid, water or alkali. To all soils the same amount of solution was added. This soil had a P_H of 7.3 and a titration curve corresponding to table I below. In the table the amounts of alkali and acid added are calculated in c.c. of 0.1 normal solution per gram soil (not air-dried, but holding about 100 percent water calculated in dry weight).

Table I. *Acid and alkali added to Buitenzorg soil, and reaction in* P_H

C.c. H_2SO_4 0.1 normal	P_H	C.c. KOH 0.1 normal	P_H
3.6	2.3	0.12	7.6
2.4	4.5	0.25	7.9
2.12	6.5	0.62	8.8
1.47	6.8	0.84	9.5
1.06	7.0	1.24	11
0.42	7.2		
0.21	7.3		
0	7.3		

Through interpolation the amounts necessary for preparing a series of soils with whole P_H intervals was obtained. After having added the desired solution-volumes each soil was thoroughly mixed and the hydrogen-ion concentration controlled.

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[1] According to determination kindly made by Dr. H. Boschma.

After one and one half, two, three, four and five days the number of earthworms living was counted. The results are given in table II.

TABLE II. *Experiments with Perichaeta indica Horst*

Days	Soil reaction, and numbers of earthworms alive in each P_H							
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	6	6	7	6	6	6	6	7
1½	1	0	1	6	6	2[b]	5[b]	1[b]
3	0[a]	–	1	6	6	0	1[b]	1[b]
4	–	–	1	6 + 1[c]	6	–	1[b]	0
5	–	–	1[b]	6 + 1[c]	6	–	1[b]	–

[a] All lying on the surface.
[b] In very bad condition.
[c] Small.

After five days there were practically no living worms except in the pots with a P_H of 6 and 7. In both these concentrations they were living very well, were thick and full of earth, and showed very strong movements when irritated. In P_H 6 there had been propagation, and the young earthworm was very vigorous.

An interesting observation was that, when in all other concentrations the worms had crept down in the soil, those in the pot of P_H 3 were all lying on the surface. Perhaps this was due to the fact that in P_H 3 the worms were killed by external injuries while deaths occurring in other soils were due to internal injuries caused by the swallowed soil particles.

A similar experiment was later carried out in the Laboratory of Soils and Bacteriology in the University of California as a control to prove that not only the Javanese earthworm but also other species are influenced by the P_H of the soil.

The experiment was arranged and carried out as the one mentioned above. In this case there was used a good garden soil from Berkeley with a titration curve as given in table III below. The soil was acidified with H_2SO_4 and alkalinized with NaOH.

TABLE III. *Acid and alkali added to Berkley soil, and reaction in* P_H

C.c. H_2SO_4 0.1 normal	P_H	C.c. NaOH 0.1 normal	P_H
4.44	2.5	0.05	7.3
2.22	4.8	0.11	7.3
1.11	5.2	0.57	7.4
0.44	6.2	1.13	8.0
0.22	7.0	4.52	12.
0.	7.2		

The results were very similar, as seen from table IV.

From these two experiments it is clear that the life of the earthworm is very strongly influenced by the reaction of the soil, so that they can live only

TABLE IV. *Experiments with Lumbricus terrestris L.*[2]

Days	Soil reaction, and numbers of earthworms living at each PH							
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	7	6	7	6	7	7	8	6
½	7^a	6^a	7^b	6	7	7	8^a	6^a
2½	0	0	1^b	6	7	3^b	0	0
3½	0	0	0	6	7	0	0	0

[a] Very good.

[b] Not good.

[2] According to a kind determination by Dr. Frank Smith, Urbana.

in slightly acid and neutral soils. This is quite in accord with the experiences of the authors mentioned above: that the earthworms cannot live in raw humus which has a PH lower than 6, but live and propagate very well in the mild humus lying around the values 6 and 7. In the arid regions earthworms are very scarce according to Hilgard (3) and others. Mr. Prescott of the Sultan Agricultural Society, Cairo, had the kindness to mention that he never had observed earthworms in Egypt either in garden soils or in agricultural land, and according to my observations nearly all good Egyptian soils have a PH above 7.5.[3]

The conclusions of these observations would be that the presence or absence of earthworms in the soil is dependent on its reaction, and this also determines the soil type. Thus the reaction is the primary factor, and the others the results of its influence.

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[3] In full agreement with the above are also the results of Shohl (7) and Hurwitz (4) who worked with *Allobophora foetida* (Sav.) and found that the irritation of the worms was proportionate to the hydrogen- and hydroxyl-ion concentration.